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DISCUSSION

THE CROTON WATER SUPPLY, ITS QUALITY AND PURIFICATION

BY GEORGE W. FULLER

A paper read at the January meeting of the New York section; printed in the JOURNAL OF THE AMERICAN WATER WORKS ASSOCIATION, vol. 1, no. 1, at pages 135.

MR. ALEXANDER POTTER (*by letter*): It is generally admitted that there can be no issue as to the desirability of filtering surface waters to improve their physical characteristics and sanitary qualities. In general this is also true of the Croton water. On the other hand there is a decided difference of opinion among engineers as to whether or not the filtration of Croton water is imperative at this time. It will be admitted that filtration will not materially decrease the death rate from typhoid fever in Manhattan and the Bronx. Since 1880, New York has successively occupied first, second, third or fourth place in the roll of honor for low typhoid fever death rates among American cities, in this regard eclipsing many cities that possess modern filtration plants. The typhoid fever death rate of New York City is now far below the number stated by so eminent an authority as Rudolph Hering as a number which would prevent the casting of any suspicion whatsoever upon the water supply.

The lessons to be drawn from the defeat of the filtration project as discussed by Mr. Fuller are important ones. Nevertheless, a project of such vast importance should be judged upon other and more scientific grounds and statements of facts than that one suggested by Mr. Fuller; viz., that "a comparison of the engineers mentioned above approving of the project with a list of those who have opposed it, is convincing," or, in other words, that the mere mention of the names of certain engineers as opposed to other engineers is sufficient to condemn or uphold a project irrespective of scientific facts.

In 1906 Mr. Fuller was retained by the city of New York to prepare plans for filtering the Croton water. After exhaustive studies

had been made by him, including the installation and testing of an experimental filter, he recommended the installation of slow sand filters at the Jerome Park site. Concerning this plant Mr. Fuller states: "This project was pigeonholed, very likely because the panic of that year (1907) and the difficulty of selling bonds made public improvements of this character impracticable." Had the city officials at that time accepted the recommendation of the filtration engineers at its face value, then, according to the estimates of Mr. Fuller himself, the city of New York would have spent \$5,000,000 needlessly. In table 7 presented by the author we find that the construction cost of a slow sand filter plant without coagulation is set down at \$11,638,500, and with coagulation, at \$10,753,700, as opposed to an estimate of \$7,405,000 for a mechanical filter plant, the type of plant recommended by the author in 1912 when he was reëngaged by the city of New York as consulting engineer for the design and construction of a filter plant. This difference in cost of construction, together with the interest and sinking fund during the intervening period, amounts in round figures to the sum of \$5,000,000. If mechanical filtration was advisable in 1912, it was in all probability as applicable in 1907 when Mr. Fuller recommended slow sand filters.

Is it not pertinent to inquire whether the defeat of the project in 1907 was due simply to the condition of the bond market, as suggested by Mr. Fuller, or to the doubt in the minds of the city officials having the project under consideration that the ultimate construction cost of the project would greatly exceed the estimates submitted by the engineer for this project, due in part, at least, to the excessive rates of filtration recommended? In fact, the estimate submitted by Hering and Fuller in 1907 for a slow sand filter plant was approximately \$3,000,000 lower than the estimated cost of such a plant made by Mr. Fuller in 1911-12 when recommending mechanical filtration in place of the slow sand filtration approved by him in 1907.

Mr. Fuller criticises the city officials in no uncertain terms for their inconsistency. His exact language is:

It is rather curious that a ten year long attempt to give the citizens of New York a drinking water supply of a quality such as is elsewhere demanded should have finally proven abortive. And even more curious that the same officials who had voted to give New York a proper drinking water should later with the same information before them reverse themselves, that a Board of

Aldermen, who but a short time before were considering a vote of censure on the executive department for their slowness in providing filtered water should a few months later repeal their ordinance and condemn the project.

Certainly we are justified in believing that some strong and convincing facts other than those mentioned by Mr. Fuller in his article must have been presented to the New York City officials to cause them to so change their decision.

It is therefore logical that we endeavor to secure an unprejudiced statement of the facts presented to the officials and Mr. Mitchel and to investigate the extent to which the water has since been improved by the simple and remedial methods favored by Mr. Mitchel.

To quote again from Mr. Fuller's paper upon this point:

The last chapter of this controversy was written on May 22, 1913, when Mr. Mitchel reported to the Board of Estimate his deduction that in his judgment hypochlorite would make our water safe, and that aeration would serve to remove from 50 to 75 per cent not only of the tastes and odors, but also of the color and turbidity from the water. With this he cast the vote which killed the project.

Statements by engineers should be precise and exact, and the author is open to criticism in stating that Mr. Mitchel invaded the field of the engineer and expressed his judgment as to the value of hypochlorite and aeration. Before finally acting upon this filtration project, Mr. Mitchel sat simply as a court and heard much evidence in reference to the efficiency of hypochlorite and aeration treatments. At this hearing Mr. Fuller stated that proper aeration might remove from 50 to 75 per cent of the objectionable taste and odors from the water. Basing his judgment upon such opinions as this Mr. Mitchel concluded that filtration at the present time, while highly desirable, was not imperative. In regard to the efficiency of sterilization with hypochlorite of lime, Mr. Mitchel had before him the statements made under oath by Mr. Fuller and also by Mr. George A. Johnson (who also contributed to this discussion) in the case of Jersey City vs. Jersey City Water Supply Company.

Jersey City was supplied with water from the Boonton Reservoir. The drainage area tributary to this reservoir is 121 square miles. The population on the watershed is 25,000. The drainage area of Croton water is 360 square miles and the population 25,000. In other words, the pollution from the tributary population is three times as great in the Boonton reservoir as in the Croton reservoir.

The storage in the Boonton reservoir was stated at the hearing by Mr. Johnson or Mr. Fuller to be 200 days storage. Mr. J. Waldo Smith stated that the Croton reservoir held nearly a year's supply. It is, therefore, evident that the opportunity for sedimentation in the Croton reservoir is greater than that in the Boonton reservoir. The alleged peculiar conditions of Croton water militating against successful use of hypochlorite of lime, therefore, existed to even a greater degree in the Boonton water, if indeed these peculiar conditions are at all important.

The testimony of Mr. Fuller is found in volume 9, testimony for defendants in court of chancery on reference McGee, N. C., page 5097:

Q. Which is the simpler process to handle and to manage in operation—filtration by this method or oxidation? A. This oxidizing process is by far the simpler to handle.

Q. In your opinion is this oxidizing process effective to remove the bacteria in the Boonton water so that it is pure and wholesome for drinking? A. Yes, sir.

Q. Is it reliable? A. Yes, sir.

Q. Is it safe? A. Yes, sir.

Q. What in your judgment is the propriety, or, is it in your judgment a proper method to adopt at the Boonton dam for the rendering of this water pure and wholesome for use at Jersey City? A. I think it is, assuming in my answer that it is the objectionable bacteria which it is the purpose to remove. I might add a word more, that is, that that qualification was intended to refer to the fact that this is not a substitute for filtration; it is not a process to remove mud or the coloring matter which we call vegetable stain, such as comes from decomposed leaves in swamps.

Q. You are assuming that the problem here is to destroy the objectionable bacteria, so that there should be no danger from infection or contamination from that source? A. Precisely.

Q. And destroy the pathogenic germs? A. Yes.

Q. And is it effective to do that thing? A. It is effective and safe.

Q. And reliable? A. And reliable.

Again Mr. Fuller testified on page 6685, volume 12, as follows, referring to the treatment of water with hypochlorite of lime:

Q. After this year's experience with this plant, what is your judgment of it as to its safety and its effectiveness for sterilizing the water? A. I think that this process produces a safe water and one which in its efficiency as a process compares very favorably, indeed most satisfactorily, in fact, with the best filter plants as regards both construction and operation of those filter plants. In other words, it meets the plan which is represented by the best practice in the art of water purification. I am speaking, of course, now with

regard to the removal of objectionable bacteria; that is the very point at which the process is aimed. . . .

Q. What do you say as to the purity and wholesomeness of this water as delivered this past year through the operation of this process? A. In my judgment, throughout the year this water has been pure and wholesome as delivered at Jersey City.

Q. Has the removal of bacteria by this sterilization process been as efficient as could have been expected from a well and properly built filtration plant? A. Yes; I think it has been substantially as complete a removal.

Mr. George A. Johnson testified as follows on page 5181:

Q. In your experience, have you ever found from a surface water as uniformly a low count of residual bacteria as appears in this water, since the application of this method? A. No, sir, I haven't.

Q. What is the quality of this water, after this treatment, as to safety and potability, in your opinion? A. I think it is perfectly safe for all domestic and industrial uses.

Q. Is this method, in your opinion, reliable? A. Yes, sir.

Q. Is it safe? A. Thoroughly.

Q. Is it uniformly effective in its action? A. Yes, sir, always.

Q. In your opinion is this method suitable, or otherwise, to be applied to Jersey City water supply, for the purpose of rendering it safe and potable at Jersey City? A. I think it is in all ways thoroughly suitable and safe.

Q. Is this method, in your judgment, a practical method for continuous use, to keep this water pure? A. Yes, sir, it is.

Q. Is it as simple as would be a filtration plant, or as easily handled? A. Why, it is much simpler to manage than a mechanical filter plant or a sand filter plant.

In this now famous case Jersey City maintained that Boonton Lake received at times raw sewage from Dover, Boonton and Hibernia, and that the sewage from these towns must either be removed or purified, or possibly both, before the water supply system could be accepted by the city. Based on the expert testimony referred to, the courts held that chlorination rendered this polluted water pure and wholesome at all times and that the city could not compel the Jersey City Water Supply Company to construct the works wanted by the city.

The answer of Mr. Fuller, endorsed by Mr. Johnson, that additional information concerning the value of hypochlorite warranted them in modifying the strong and emphatic position taken by them in 1909, is inconclusive. Mr. Johnson in his discussion of Mr. Fuller's paper goes so far as to state that as early as 1910 he set forth the limitations of the hypochlorite treatment. One of the limitations

mentioned is, "(2) Inability to remove bacteria which are imbedded in particles of suspended matter." At the same time and in the same paper, Mr. Johnson says, "Where waters are uniformly satisfactory in appearance, but open to suspicion as regards their content in bacteria, the use of the hypochlorite process alone in many cases may prove sufficient." Contrast this uncertainty in 1910 with the positiveness of the 1909 testimony.

The final verdict of the judge was not handed down until in 1910. It was influenced by the testimony of these two expert witnesses who were responsible for the design and operation of the hypochlorite plant at Boonton. Was there not some obligation resting upon these experts to submit a supplemental affidavit to the court notifying it of their change of position?

At the hearing before Mr. Mitchel, Mr. Fuller stated that, while hypochlorite was effective at Jersey City, it was not effective on the Croton supply, but he gave no scientific reason for his deduction. It is a fact that the results obtained at the Dunwoodie sterilization plant (placed in operation since the hearing before Mr. Mitchel) are vastly superior to the results obtained from the crude plant in operation prior to that time, and this notwithstanding that at the Dunwoodie plant there still remain imperfections in the rapid and thorough mixing of the sterilizing medium with the water.

It is interesting to note, moreover, from the discussion already brought out by Mr. Fuller's paper, that the micro-organisms in the water causing taste and odor have, according to Dr. Frank E. Hale, director of laboratories of the department of water supply of the city of New York, been reduced this past year more than 50 per cent by the simple expedient of drawing water from depth. When such a simple process produces such marked improvements in the water, can a layman be properly criticised for delaying a project which was admitted by the engineers as not imperative?

When this whole matter was up before Mr. Mitchel for final decision, it was urged by Mr. Fuller that filters were necessary because filters were the only practical means for the removal of tastes and odors which more seriously affect Croton water than any other water supply. Yet Dr. Hale tells us that by the simple expedient of taking water at 75 to 90 feet below the surface the water furnished consumers is 10° cooler and there is a reduction in the number of micro-organisms in the city of 75 per cent from 1911 to 1913, due largely to the employment of this simple expedient.

At this same hearing before Mr. Mitchel the writer asserted that the failure of the hypochlorite treatment in the removal of bacteria in the Croton water was due to the imperfect application of the chemicals. The accuracy of this statement of the writer's was challenged by the author and laughed at by other eminent experts present at the hearing as absurd. But what are the facts today? The author in his paper says that, in 1912, 20 per cent of the samples, the source of which is not given, showed *B. coli* in 1 cc., while Dr. Hale tells us that since the completion of the more perfect sterilizing plant at Dunwoodie only 3 per cent of the samples of the water as furnished consumers showed *B. coli* in 1 cc. in 1913, and none at all in 0.1 cc., and that there was a 95 per cent removal of *B. coli* against 90 per cent in 1912.

Mr. Fuller also argues for the immediate necessity of filtration because of the high rate of turbidity when the level in the reservoir is low; yet it was brought out in the hearing before Mr. Mitchel that the completion of the Ashokan Dam and the Catskill Aqueduct and the relatively low draft upon this new supply for a number of years should supply deficiencies in the Croton reservoir. In this manner for a number of years the low levels in the reservoir, which cause turbidity, will be prevented.

The author regrets the failure of the filtration project and says that it will interest the Association as an engineering question and "it will form the basis of an instructive comparison some years hence when filtration will be finally effected for the Croton water." The writer would suggest that it would be a much more interesting, and certainly a much more profitable discussion if the author would give us more specific information as to why, after an investigation in 1906-07 conducted by himself and his partner, Mr. Rudolph Hering, and costing the city some \$50,000, he recommended that sand filters be adopted, whereas when employed a second time, in 1911, he reversed himself and recommended mechanical filters. Some good reason, not referred to in his paper, must have presented itself to him.

As exactitude of statement in engineering discussion is essential, it is interesting to compare the statement of Mr. Fuller and that of Dr. Hale as to pollution of Croton water existing at the present time. Mr. Fuller says:

3. The watershed contains some 13 miles of railroad track within 300 feet of the flow line, and 18 railroad bridges aggregating 1700 feet in length. The

sewage from the passenger trains enters the reservoirs practically raw, and may often contain pathogenic bacteria. So far, it has not been practicable to enforce proper sanitary control over the wastes from these railroad trains.

The difficulties of asserting authority and abating nuisance are considerable under existing laws, and make watershed protection harder than it should be.

4. Highway bridges, 19 in number, aggregating 4200 feet in length, discharge their wash into the reservoirs.

Dr. Hale in his discussion says:

All trains in passing over the watershed have their toilets locked during transit. Bridges over the reservoirs and streams are swept daily to remove the horse droppings, etc.

The facts stated by the writer are sufficient in his judgment to warrant any board in deferring action upon an undertaking which is so expensive and at the same time admitted as not imperative.

In the opinion of the writer, the author is not justified in reflecting upon those engineers whose convictions were at variance with him, or upon the city officials who voted to defer the construction of the filters for the present.

MR. GEORGE W. FULLER (by letter): The comments of Mr. Alexander Potter on certain features of the writer's paper on the Croton water supply call for a few words in response.

Broadly speaking, Mr. Potter suggests that in the paper the author did not present the position of the opponents of the Croton filtration project, and that there are a number of arguments available against the building of this filtration plant which fully explain and justify its abandonment. An examination of the original paper, however, will readily show that this opposition was presented. On pages 170 and 171 the dissenting report of Mr. Frazee was abstracted at length. On page 173 we can find a reference to the Jersey City water supply case. In both cases the opposition on these grounds is answered, and it is not necessary here to repeat this answer.

Mr. Potter finds some fault with the condition that we know more today about the action and value of hypochlorite treatment than we did in 1909. At that time it was not evident, as it has been since, that the value of hypochlorite is limited by the conditions of its application; and that under some conditions, and such conditions obtain in the Croton water at times, the hypochlorite treatment is not fully dependable. Mr. Potter quotes some operation figures of the

Croton supply for the years 1912 and 1913 and deduces a conclusion that the greater efficiency of the Dunwoodie chlorinating plant accounts for the greater efficiency in the latter year. This greater efficiency is more properly to be attributed to a natural cause, the better quality of the raw water treated in the year 1913. The very essence of the limitations of the hypochlorite treatment lies in the fact that, while with fairly clear water, having relatively a small amount of microscopic organisms and organic matter, the treatment is highly efficient, with relatively impure water the treatment is relatively inefficient, not necessarily so as expressed as a percentage, but as measured by final effect. The Croton water was on an average in the year 1913 far superior in all properties to the average of the year 1912, and it is accordingly to be expected that the hypochlorite treatment should have been satisfactory. When the time comes, as it will in the course of years, that the Croton water is again largely polluted and contains much organic content and possibly greater turbidity, the effect of the hypochlorite treatment will be far less, and if it should happen that at that time the Croton water be polluted by typhoid bacilli, it is quite within the bounds of probability that a typhoid epidemic, perhaps of small and perhaps of large extent, may result. Such a danger is sufficient to warrant the expenditure of 25 cents per capita per year to avoid.

The assumption that the introduction of the Catskill water, with its works, would give the city such a wide margin of water supply that the Croton can be used to best advantage, and that low water in the reservoirs and unsatisfactory water cannot obtain, seems to the writer a rather rash one and not based on any evidence thus far developed. The best information available leads to the thought that the Croton supply must rest on its own bottom, even after the introduction of the Catskill.

Mr. Potter raises the question of the change in the type of filters recommended between the years 1907 and 1914. The reasons are to be found in the development of the art of mechanical filtration during these seven years. The writer feels in no danger of being accused of having been a foe to mechanical filtration. At the time of the early investigations into the Croton water two fair-sized mechanical filters of modern type had been built, namely, the Little Falls plant and the Hackensack plant. While these plants had been entirely successful, the writer did not feel that the art had attained sufficient standing at the time of his 1907 report to war-

rant the adoption of mechanical filtration for this particular water. In the interval since 1907 modern mechanical filtration has reached such a position that the writer feels no hesitation in recommending it for any waters whatever where the desired results could be obtained by this method at a less total annual cost than with sand filters.

Finally, the writer wishes to take issue with the statement in Mr. Potter's second sentence that:

There is a decided difference of opinion among engineers as to whether or not the filtration of the Croton water is imperative at this time.

It is only necessary to point out in the original paper the words on page 174:

It has never been represented as absolutely imperative.

* * * * *

But it is certainly desirable that a city the size of ours should have a pride in doing these things, and it should have a pride in drinking a water for which it need not apologize as reasonably safe at most times and fairly decent-looking at most times.

And this is the position taken by practically all of the engineers who have investigated the question. It certainly adds nothing to our knowledge for Mr. Potter to attempt to prove that this filtration is not imperative.